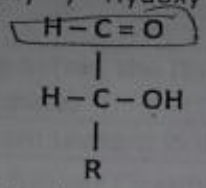
CHAPTER 2
CARBOHYDRATES OF BIOLOGICAL IMPORTANCE

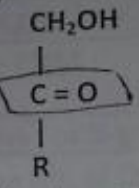
What are Carbohydrates ?

- They are Polyhydroxy alcohol functional aldehyde or ketol group

(Poly = many , Hydoxy = -OH , Aldehyde = -CHO , Ketol = C = O)



Polyhydroxyaldehydes



Polyhydroxyketones

- Usually the ratio between Carbon & H_2O is 1 ; hence the name carbohydrate

Classify Carbohydrates according to the hydrolysis (تحلل مائي) products

1. Monosaccharides	Contains Only 1 Sugar unit *(Can't be Hydrolyzed)*
2. Disaccharides	Contains 2 sugar units
3. Oligosaccharides	Contains 3 – 10 Sugar units
4. Polysaccharides	Contains More than 10 Sugar units

1. Monosaccharides

- General Formula : $(CH_2O)_n$
- Classifications :
  - A. According to the Functional group :
    1. Aldoses
    2. Ketoses
  - B. According to the No. of Carbon atoms :

Sugar	No. of Carbons	Includes
Trioses	3	Aldotrioses & Ketotrioses
Tetroses	4	Aldotetroses & Ketotetroses
Pentoses	5	Aldopentoses & Ketopentoses
Hexoses	6	Aldohexoses & Ketohexoses

1. Aldoses :

- The Parent Aldose : is the Aldotriose Glyceraldehyde
- Glyceraldehyde contains 3 Carbons ;
  - 1st Carbon is the Aldehyde group (-CHO)
  - 2nd Carbon is secondary alcohol group (H – C – OH)
  - 3rd Carbon is primary alconol group (CH_2OH)
- Glyceraldehyde may be present either in D or L forms → Contain 1 Asymatric Carbon atom

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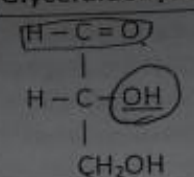
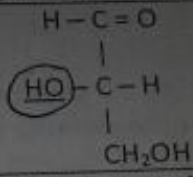
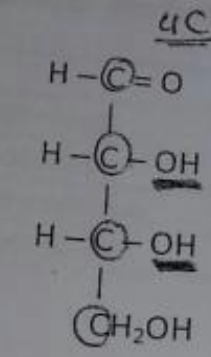
- Theoretically higher aldoses can be formed by inserting 2nd alcohol group below the aldehyde group

	D- Glyceraldehyde	L- Glyceraldehyde
Formula		
Carbon atom before the last one (penultimate)	OH to the Right	OH to the Left

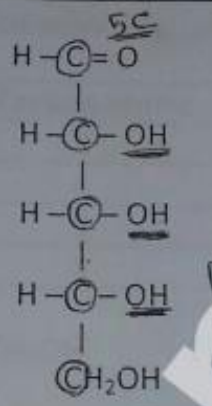
- Aldoses w` are present in nature are derivatives of D-glyceraldehyde

- Aldoses are further Classified according to the No. of Carbon atoms into :

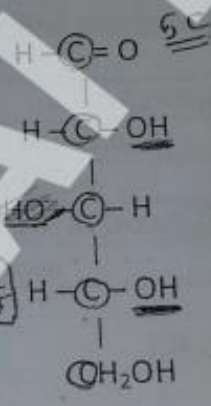
	No. of Carbon atoms	Examples
Aldotriose	3	D-Glyceraldehyde
Aldotetrose	4	D-Erythrose
Aldopentose	5	D-Ribose & D-Xylose
Aldohexose	6	D-Glucose , D-Mannose & D-Galactose



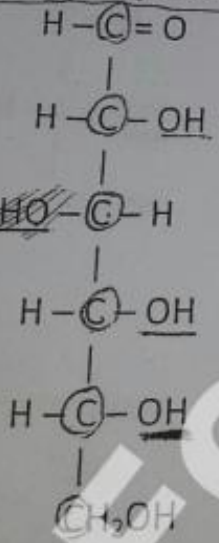
D- Erythrose



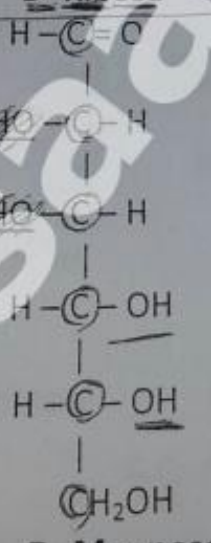
D- Ribose



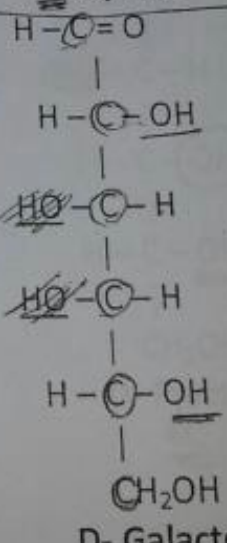
D- Xylose



D- Glucose



D- Mannose



D- Galactose

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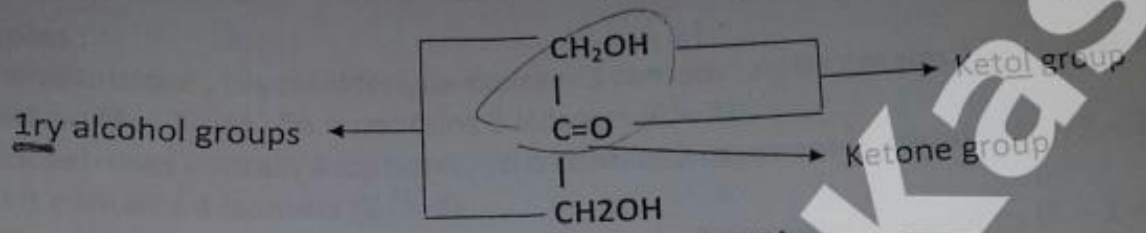
2. Ketoses :

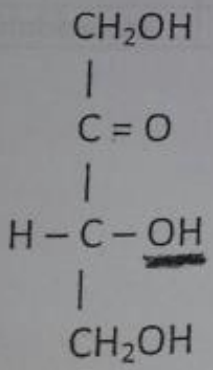
- **The Parent (simplest) Ketose :** Is Dihydroxyacetone (DHA)
- Dihydroxyacetone Contains 3 Carbons ;
  - The 2 terminal Carbons are 1^{ry} alcohol group (-CH_2OH)
  - The second Carbon is Ketone group (-C=O)
- Dihydroxyacetone has No D or L forms (Contain No asymmetric carbons)
- Theoretically higher Ketoses can be formed by inserting secondary alcohol group below the ketol group (between it & the 1^{ry} alcohol group & they may be present In D or L forms (contain asymmetric carbon"s")
- Naturally occurring Ketoses are mainly in the D form :



Dihydroxyacetone (DHA)

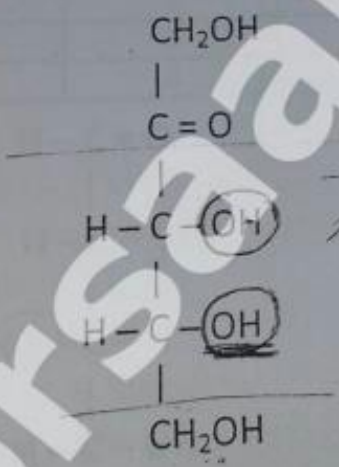
- Ketoses are further Classified according to the No. of carbon atoms into :

	No. of Carbon atoms	Examples
Ketotriose	3	Dihydroxyacetone
Ketotetose	4	D-Erythrulose
Ketopentose	5	D-Ribulose & D-Xylulose
Ketohexose	6	D-Fructose

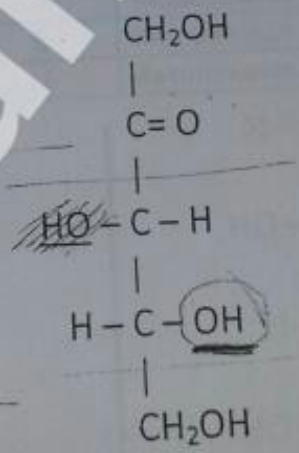


D- Erythrulose

4C

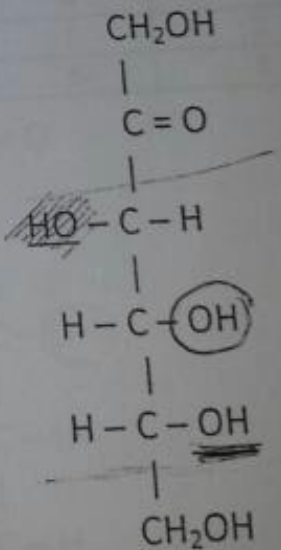


D- Ribulose



D- Xylulose

5C



D- Fructose

6C

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Stereochemical Isomers of Monosaccharides

- **Asymmetric Carbon atom :** Carbon atom attached to 4 different atoms or groups
- All Monosaccharides Contain 1 or more asymmetric Carbon atoms **except** **Dihydroxyacetone** → Ketotriose

How to Calculate the No. of asymmetric Carbons ?

- **In Aldose :** Total No. of carbons (2) →
- **In Ketoses :** Total No. of carbons (3) →

How to Calculate the No. Of Isomers ?

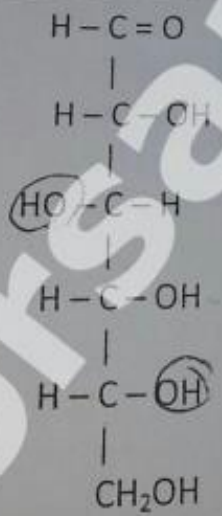
- No. of isomers = 2^n n= No. of asymmetric Carbons

Examples :

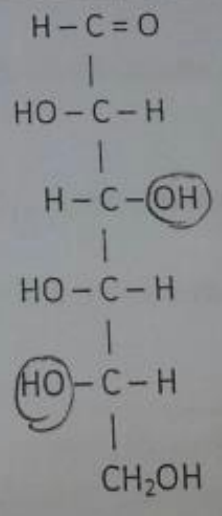
- The aldotriose ; Glyceraldehyde contain 3 carbons , so it contains 1 asymmetric Carbon $(3-2=1)$, So it contains 2 Isomers $(2^1=2)$
- Aldotetroses contain 4 carbons , so it contain 2 asymmetric carbons $(4-2=2)$, So it contains 4 isomers $(2^2=4)$
- Aldopentoses contain 5 carbons , so it contain 3 asymmetric carbons $(5-2=3)$ So it contains 8 isomers $(2^3=8)$
- Aldohexoses contain 6 carbons , so it contain 4 asymmetric carbons $(6-2=4)$ So it contains 16 isomers $(2^4=16)$

N.B. : 1/2 of the Isomers are present in the D form & the other 1/2 in the L form

Aldoses	No. of carbons	No. of asymmetric carbons (No. of C – 2)	No. of isomers 2^n	Ketoses	No. of carbons	No. of asymmetric carbons (No. of C – 3)	No. of isomers 2^n
Aldotrioses	3	1	2	Ketotrioses	3	No	No
Aldotetroses	4	2	4	Ketotetroses	4	1	2
Aldopentoses	5	3	8	Ketopentose	5	2	4
Aldohexoses	6	4	16	Ketohexoses	6	3	8



D-Glucose



L-Glucose

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Very Important Definitions

Isomers : Compounds having the same Molecular formula (same No. of atoms) but differ in the orientation of H or OH around 1 or more asymmetric carbon(s)

Epimers : Optical Isomers having more than 1 asymmetric carbon , all are the same only 1 is different

- **Examples :**
  1. Glucose & Mannose are epimers at C2
  2. Glucose & Galactose are epimers at C4

Annomers : Type of Optical Isomers represents the α & β form of any sugar in the ring structure

- **Examples :** α,D-Glucopyranose & β,D-Glucopyranose

Enantiomers : The D & L forms of any sugar & they are mirror images

- **Example :** D-Glyceraldehyde & L-Glyceraldehyde

Aldose – Ketose Isomers (Functional group Isomerism) : Have the same molecular formula but differ in the functional group

- **Examples :**

	Aldose	Ketose
Trioses	Glyceraldehyde	Dihydroxyacetone
Tetroses	Erythrose	Erythrulose
Pentoses	Ribose & Xylose	Ribulose & Xylulose
Hexoses	Glucose , Galactose & Mannose	Fructose

Optical Activity

Definition : The ability of substance to rotate PPL (Plane Polarized Light) to an angle measured by polarimeter

NB. : PPl vibrates only in 1 direction while ordinary light vibrates in all directions

How Can we obtain PPL ?

- By Passing ordinary light through a Prism w` reflects all vibrations and passes only those Parallel to the base of the prism

Direction of Rotation :

- If the direction of rotation is to the Right (clockwise) → termed dextrorotatory & given the small letter " d " or plus sign (+)
- If the direction of rotation is to the Left (anticlockwise) → termed Levorotatory & given the small letter " l " or minus sign (-)

Examples : D(+) Glucose - D(-) Fructose

- *Optical activity depends on the presence of at least 1 asymmetric carbon atom So;*
- *All monosaccharides are optically active except Dihydroxyacetone as it contains NO asymmetric carbons*

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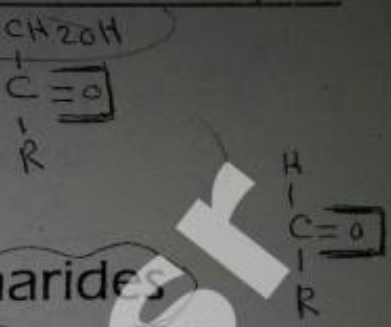
Specific Rotation

Def. : It's the degree of rotation , measured by polarimeter

- Each substance has its specific rotation
- Specific rotation of glucose is 52.5 to the right i.e. +52.5°
- Specific rotation of Fructose is 92.3 to the left i.e. -92.3°



Ring Structure of Monosaccharides

- Pentoses & Hexoses may be present in the Cyclic forms due to formation of :
  - Hemiacetal → In Aldoses
  - Hemiketal → In Ketoses
- This Cyclic form is due to reaction between C=O of aldehyde group in Aldoses or of Ketol group in Ketoses e` an alcoholic hydroxyl group to form :
  - Furanose → 4 Carbon ring
  - Pyranose → 5 Carbon ring
- Haworth formula describes the cyclic structure like a ring , in this formula :
  - Groups w` are on the **Left** side in the straight formula → written **Upward**
  - Groups w` are on the **Right** side in the straight formula → written **Downward**
- As a result of the cyclic structure the 1st Carbon " also called Annomeric carbon or Carbonyl carbon" becomes asymmetric So the sugar is present in 2 isomeric forms called Annomers :
  - α Form → OH is present on the Right of the annomeric carbon
  - β Form → OH is present to the Left of the annomeric carbon
- Glucose in solution is present at 20° C as :
  - 1/3 in the α form
  - 2/3 in the β form
  - Traces in the aldehyde form
- D-Fructose is present in 2 cyclic forms :
  - **Furanose** form → Cyclization between C_5 & C_2 ; It's present in :
    - Disaccharide → Sucrose
    - Polysaccharide → Inulin
  - **Pyranose** form → Cyclization between C_6 & C_2 ; it's present in :
    - Free Fructose in the solution

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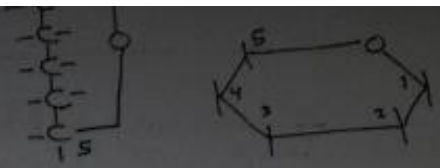
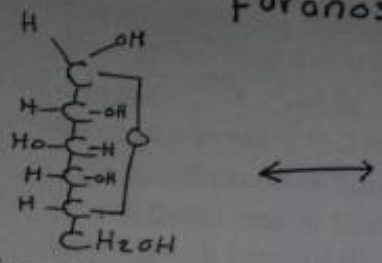
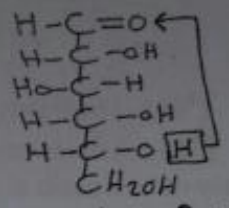
Furanose



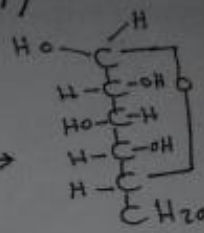
Pyranose



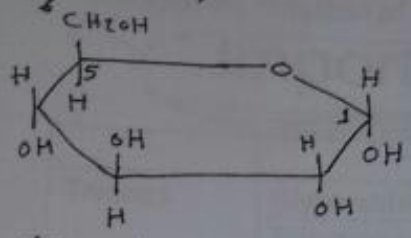
α D glucopyranose
(+110°)



Aldehyde form



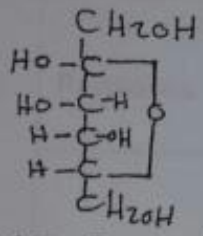
β D glucopyranose
(+19.5°)



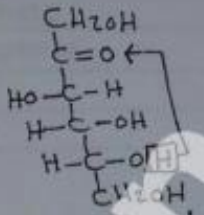
α D glucopyranose

Haworth formula

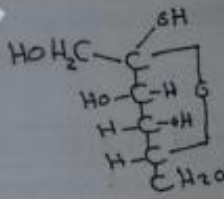
β D glucopyranose



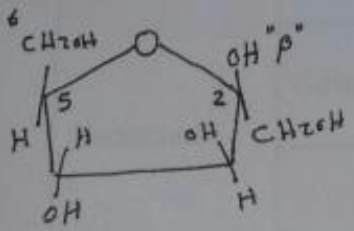
β D Fructofuranose



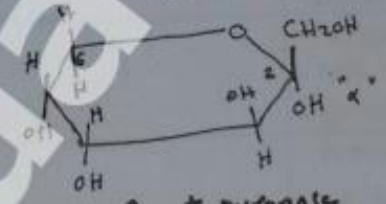
D-Fructose



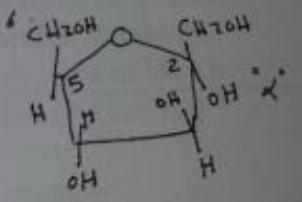
α D Fructofuranose



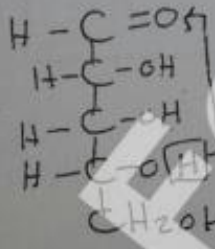
β D Fructofuranose



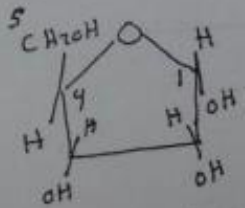
α D Fructopyranose



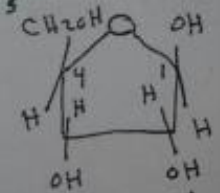
α D Fructofuranose



D-Ribose



α D Ribofuranose



β D ribofuranose

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Mutarotation (التوران الضوئي للمحاليل)

Definition :

The spontaneous change in the specific rotation of optically active substance when a fresh solution of this substance is prepared

Example :

- Glucose is present in 2 forms :
  - α,D-Glucose → Specific rotation (+110°)
  - β,D-Glucose → Specific rotation (+17.5°)
- When α or β form of Glucose is dissolved in water the specific rotation of each gradually changes e` time and reaches +52.5°
- This is due to formation of equilibrium mixtureof 1/3 α,D-Glucose & 2/3 β,D-Glucose , the specific rotation of this mixture is +52.5°

Importance of Monosaccharides

	Example	Function
Trioses	Glyceraldehyde 3-phosphate	- Formed during Glucose oxidation in the living cells
	Dihydroxyacetone-phosphate (DHAP)	
Tetroses	Erythrose 4-phosphate	
Pentoses	Ribose 5-phosphate	
	Ribulose 5-phosphate	
	Ribose	- Ribonucleic acid (RNA) Formation
	D_2-deoxyribose	- Deoxyribonucleic acid (DNA)
Hexoses	Glucose or Dextrose (Grape sugar)	- Blood sugar - Present in many fruits (e` Fructose) - Di & Polysaccharides formation - Obtained by hydrolysis of Starch
	Galactose	- Lactose formation (e` Glucose) - Milk formation - Galactolipid formation
	Fructose or Levulose (Fruit sugar)	- Present in: • Honey & Fruits • Sucrose e` Glucose • Inulin • Semen (Main nutrient for sperms)

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Derivatives of Monosaccharides

1. Sugar Acids

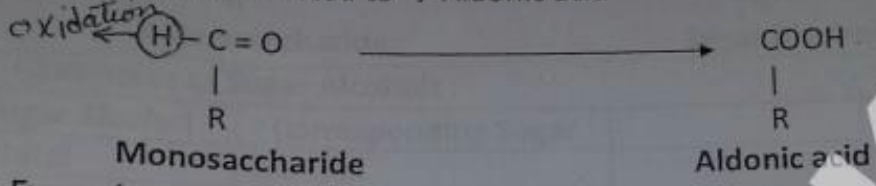
a. Aldonic acids
b. Uronic acids
c. Aldaric acids
c. L-Ascorbic acid

occur in aldoses.

Suger → acid
suger acid

a. Aldonic acids :

- Formed by Oxidation of the Aldehyde group → Carboxyl group So;
- The Sugar is converted to → Aldonic acid



Monosaccharide — Aldonic acid

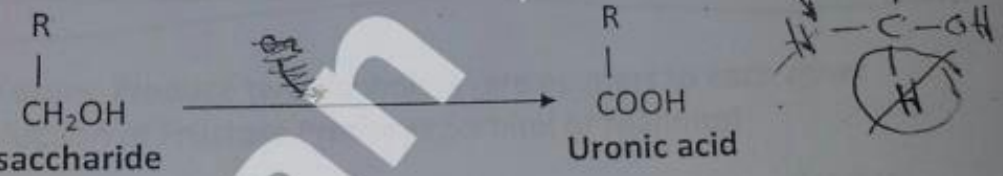
- **Examples :**

Glucose → Gluconic acid
Galactose → Galactonic acid

- Guluconic acid is formed during Glucose metabolism.

b. Uronic Acids :

- Formed by oxidation of the 1ry alcohol group → Carboxyl group So ;
- The Sugar is is converted to → Uronic acid



Monosaccharide — Uronic acid

- **Examples :**

Glucose → Glucuronic acid (Glc UA)
Galactose → Galacturonic acid (Gal UA)

- They are important components of polysaccharides i.e. GAGs

c. Aldaric acids :

- Formed by oxidation of both the aldehyde & 1ry alcohol groups→ Carboxyl group So ;
- The Sugar is is converted to → Aldaric acid
- **Examples :**

Glucose → Glucaric acid
Galactose → Galactaric acid

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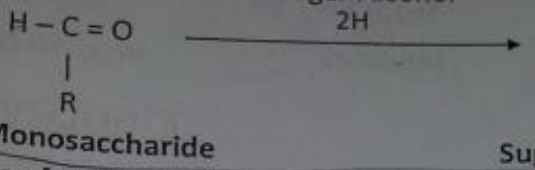
d. **L-Ascorbic acid (Vitamin C)**

- It's a sugar acid
- Formed from Glucose in Plants and lower animals but not humans
- Its deficiency Produces a disease in human named Scurvy (الأسترربوط)

2. Sugar Alcohols

- Formed by reduction of Aldehyde group → 1^{ry} alcohol group So ;
- The Sugar is converted to → Sugar Alcohol



Monosaccharide **Sugar Alcohol**

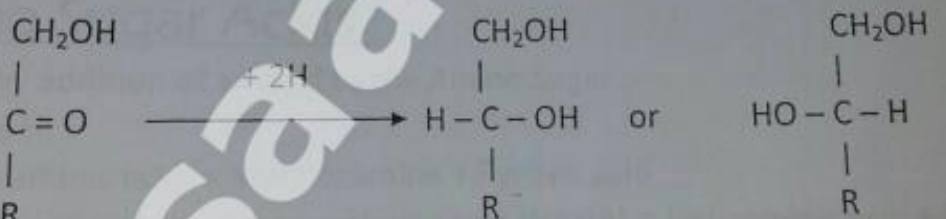
- **Examples of Sugar Alcohols :**

Sugar Alcohol	Corresponding Sugar	Function
Sorbitol	Glucose	Artificial Sweeteners
Mannitol	Mannose	
Dulcitol	Galactose	
Glycerol	Glyceraldehyde Or Dihydroxyacetone	Present in the Structure of many Lipids; (Neutral Fat "TAG" & Phospholipid)
Ribitol	Ribose	In the Structure of Riboflavin (Vit B_2)
Myoinositol	It's Isomer of Inositol w` is hexahydroxy Cyclohexane	In the Structure of Phospholipid (Phosphatidyl Inositol or Lipositol)

NBs :

1. Reduction of Ketone Produce two alcohols w` are epimers to each other

   Example : Reduction of Fructose Produces Sorbitol or Mannitol



D-Fructose **D-Sorbitol** **D-Mannitol**

2. **Phytic acid is :**
   - Hexaphosphoric ester of Inositol
   - Forms Insoluble esters e` Ca^{2+} , Mg^{2+} , Fe^{2+} & Cu^{2+} So ;
   - Prevents absorption of these ions from diet in small intestine

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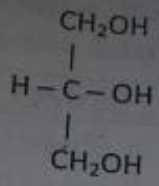
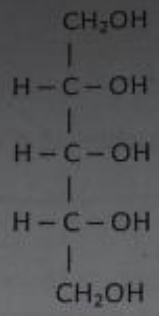
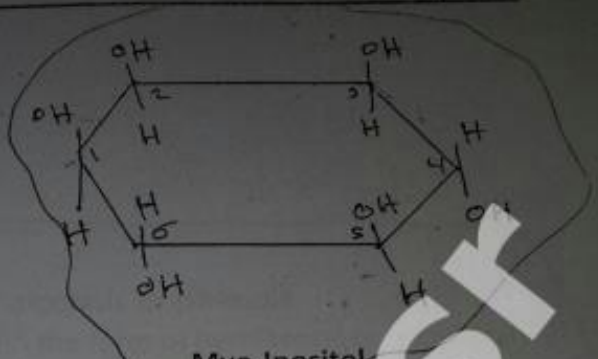


D-Glycerol



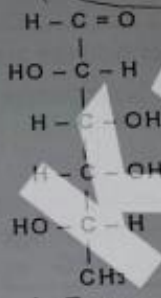
D-Ribitol



Myo-Inositol

3. Deoxysugars

- Several Deoxysugar are present in nature
- **Examples :**
  1. D_2-deoxyribose → In DNA
  2. L-Fucose (6-Deoxy L-Galactose) → In ;
     - Blood group antigens
     - Cell membrane glycoproteins



L-Fucose (Fuc)

4. Amino Sugars

- Formed by replacement of OH at C_2 of monosaccharide e` amino group (NH_2)
- **Examples :**

Glucose	⟶	Glucosamine
Galactose	⟶	Galactosamine
Mannose	⟶	Mannosamine

- **Functions :**
  - They are Important components of GAGs (Glycosaminoglycans) & Glycolipid

5. Amino Sugar Acids

- Formed by addition of an Acid to the Amino Sugar
- **Examples :**
  1. Neuraminic acid = Mannosamine + Pyruvic acid
  2. Sialic acid or N-acetyl-neuraminic acid (NANA) = Neuraminic acid + Acetic acid
- Hydrolytic Products of NANA : Mannosamine , Pyruvic acid & Acetic acid
- **Functions :** Enters in the structure of glycolipid & glycoprotein

6. Ester Formation

- Ester means Acid + Alcohol (OH)
- The Hydroxyl group of Monosaccharides can form esters e` acids

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Examples :

- **Phosphate esters :**
  - Glucose 1-Phosphate
  - Glucose 6-Phosphate
- **Sulfate Esters :** Present in GAGs & Sulfolipids
  - Galactose 3-Sulfate

7. Glycosides

Def. : Products of condensation of sugars e` alcohols or phenols

- Formed by reaction of the **annomeric carbon** (in the form of hemiacetal or hemiketal) e` Alcohols or Phenols

- Glycoside is named according to the sugar whose annomeric carbon is free
- Glycosidic Linkage is named according to the sugar whose annomeric carbon is involved in the linkage (α or β)

Examples :

- If the annomeric carbon of Glucose is involved in the linkage → Glucosidic linkage
- If the annomeric carbon of Galactose is involved in the linkage → Galactosidic linkage
- If the annomeric carbon of Fructose is involved in the linkage → Fructosidic linkage

Types of Glycosides :

1. **O-glycosides :**
   - When OH of annomeric carbon is attached to another OH of an alcohol or another sugar
   - Present in disaccharides & polysaccharides so ;
   - Disaccharides & polysaccharides are glycosides
2. **N-glycosides :**
   - When OH of annomeric carbon is attached to NH_2 of an amine
   - Present in glycoproteins & Nucleotides (simple unit of DNA & RNA)

2. Disaccharides

- Consists of 2 Monosacchsrides united together by Glycosidic linkage
- Classified according to their reducing power (Reaction e`Fehling or Benedict) into :

1. **Reducing disaccharides**
2. **Non reducing disaccharides**

- Reducing Dissacharides → e` Free anommeric carbon
- Non Reducing Disaccharide → No Free annomeric carbon (both annomeric carbons are involved in the glycosidic linkage)
- Reducing disaccharides have α & β form & can mutarotate while ;
- Non reducing disaccharides have no α & β form & can`t mutarotate

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Disaccharides

Reducing → Contain ⇒ Bond

- Maltose
- Isomaltose
- Lactose
- Cellobiose

Non Reducing

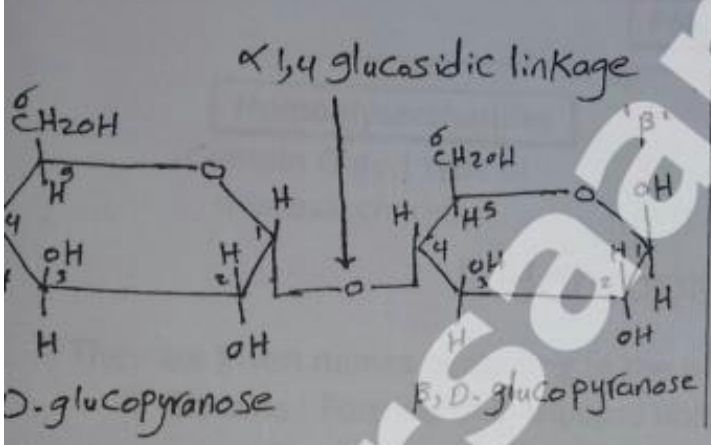
- Sucrose

Reducing Disaccharides

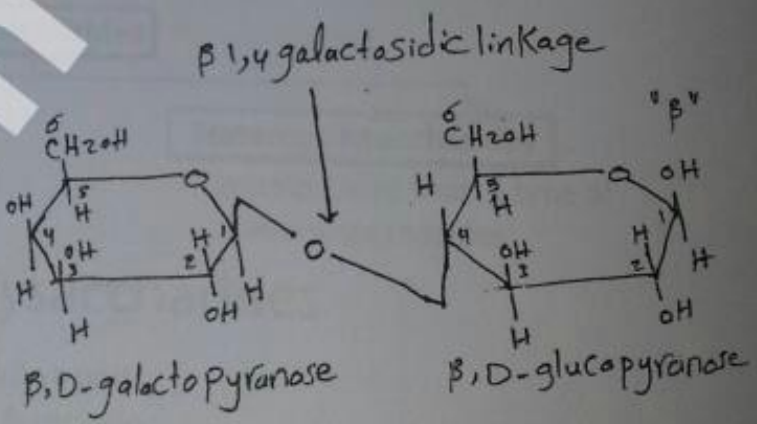
Why they are reducing ?

As they have free annomeric carbon in the (2nd) sugar unit
So they are present in α & β forms and can mutarotate

	Maltose سكر الشعير	Isomaltose	Lactose
Other Name	Malt Sugar	–	Milk Sugar
Structure	2 molecules of D-Glucopyranose	2 molecules of D-Glucopyranose	β,D-Galactopyranose & D-Glucopyranose
Linkage	α1- 4 Glucosidic	α1- 6 Glucosidic	β1- 4 Galactosidic linkage
Obtained by	Action of amylase enzyme on Starch	Action of amylase enzyme on Starch at the branching points	Present in Milk
Hydrolyzing Enzyme	Maltase & Acids	Isomaltase	Lactase & HCL
Hydrolysis Product	2 molecules of D-Glucose	2 molecules of D-Glucose	D-Galactose & D-Glucose



β-Maltose



β- Lactose

Cellobiose :

Structure : 2 molecules of β,D-glucopyranose
Linkage : β1-4 glucosidic linkage
Obtained by : Hydrolysis of Cellulose by cellulase enzyme in bacteria

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Glucans

1. Starch :

It is the storage form of carbohydrate in plants

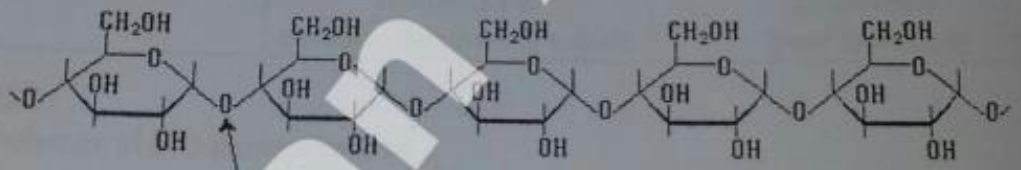
Sources : In Plants i.e. cereals (rice & wheat) , legumes (beans) & tubers (potatoes)

Types : Starch granules contain 2 forms :

- Amylose
- Amylopectin

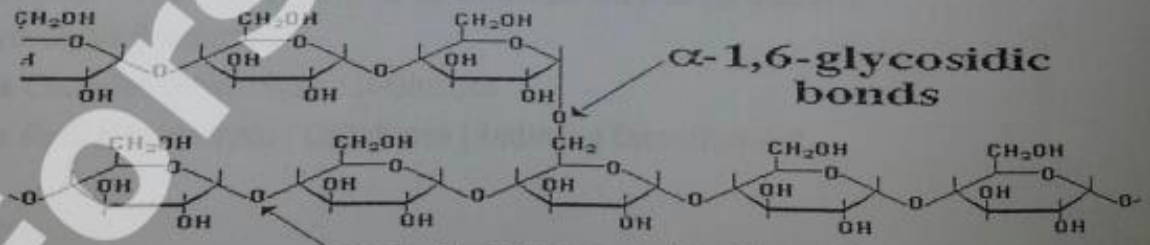
Amylose	Amylopectin
15 %	85 %
Inner part of starch granules	Outer part of starch granules
Linear (in the form of a helix)	Branched
Formed of 300 Glucose residues	24-30 Glucose residues in each branch
Molecular weight : lower	Higher
United by α1-4 glucosidic linkage	α1-4 glucosidic linkage & α1-6 Glucosidic linkage at branching points
Deep Blue color e` iodine	Red to Violet color e` iodine
Hydrolyzed by α- amylase to Maltose then to D-glucose	Hydrolyzed by α- amylase to Maltose & Isomaltose then to D-glucose

Amylose



α-1,4-glycosidic bonds

Amylopectin



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2. Dextrins :

Produced during hydrolysis of starch by salivary or pancreatic amylase

Reaction e` Iodine :

- Higher Dextrins (Amylodextrins) → Violet Color
- Intermediate Dextrins (Erythrodextrins) → Red Color
- Lower Dextrins (Achrodexrins) → No Color

3. Glycogen :

The storage form of Carbohydrates in animals

- Forms 10% of the wet weight of the liver & 1-2 % of the weight of the muscle
- Similar to Amylopectin but more branched
- Higher molecular weight
- Each branch contain 8-12 glucose residues
- Gives Red color e` iodine
- Hydrolyzed by α-amylase to Maltose & Isomaltose then to D-glucose

	Amylopectin	Glycogen
Building units	α,D-Glucopyranose	
Number of units in each branch	24 – 30 Less Branched	8 – 12 More Branched
Molecular Weight	Lower	Higher
Color e` Iodine	Red to Violet	Red
Action of amylase	Maltose + Isomaltose	
Sources	In Plants i.e. cereals , legumes & tubers	In animals Liver & Muscle

4. Cellulose :

- Linear Polymer of β,D-glucopyranose
- United by β1- 4 Glucosidic Linkage
- Site : Plants i.e. Vegtables & Cotton
- Arranged in parallel chains (helped by hydrogen bonds)
- Gives No color e` iodine
- Insoluble in water
- Hydrolyzed by strong acids or by cellulase enzyme (in bacteria
- Hydrolysis Products :
  - Complete Hydrolysis : D-Glucose
  - Partial Hydrolysis : Cellobiose (Reducing Disaccharide)

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Q 1 : Cellulose is not digested .....*Explain Why ?*
Answer : As it can't be hydrolyzed by amylase enzyme as amylase is specific only for The α glucosidic linkage & the linkage in cellulose is β1- 4 Glucosidic So
Q 2 : Inspite of being not digested Cellulose is important in diet .....*Explain Why ?* or **Cellulose Prevents Constipation .....*Explain Why ?***
Answer : As It's not digested → ↑ the bulk of food → stimulates intestinal contraction Prevents Constipation

II. Heteropolysaccharides

- The most important members of this group are :
  - **Glycosaminoglycans (GAGs) also called Mucopolysaccharides**
  - **Proteoglycans**

1. Glycosaminoglycans [GAGs]

Structure :- Composed of unbranched long chain heteropolysaccharides
- Usually formed of amino sugar & uronic acid

Classification :

→ oxidation 1ry alcho gr

- **GAGs**
  - **Sulfate Free GAGs**
    - **Hyaluronic acid**
  - **Sulfate Containing GAGs**
    1. **Chondroitin Sulfate**
    2. **Dermatan Sulfate**
    3. **Keratan Sulfate**
    4. **Heparin**
    5. **Heparan Sulfate**

A. Sulfate Free GAGs

Hyaluronic Acid :

Repeating Units :

[D-Glucuronic acid + N-acetyl-D-Glucosamine]

Site : *GV ISEZ*
- Ground substance of Loose Connective tissue
- Vitreous humour of the eye
- Intacellular Cement substance
- Synovial fluid
- Embryonic tissues
- Zona Pellucida of the Ovum

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Function :

- Lubricant
- Shock absorbent

Q : Age related pains may develop in old people .... *Explain why ?*

Answer : Due to replacement of hyaluronic acid by dermatan sulfate in synovial fluid
Dermatan sIfate is not a good lubricant

Hyaluronidase Enzyme (Spreading Factor) :

Site	Function
Some types of Bacteria	Hydrolyzes Hyaluronic acid present in the ground substance of connective tissue So help spread of infection
Caps of Sperms	Helps Fertilization

B. Sulfate Containing GAGs

	Repeating Units	Function
1. Chondroitin Sulfate	[D-Glucuronic acid + N-acetyl D-Galactosamine- 4 or 6 sulfate]	Present in : • Bone • Cartilage
2. Dermatan Sulfate	[L-Iduronicacid + N-acetyl-D-Galactosamine-4-sulfate]	Present in : • Heart valves • Skin • Blood vessels & • Cornea & Sclera
3. Keratan Sulfate	[D-Galactose + N-acetyl-D-Glucosamine-6-sulfate]	Present in : • Cartilage • Cornea (important for corneal transparency)
4. Heparin	[Uronic aid-2-sulfate + D-Glucoamne-2,6-bissulfate] - Uronic may be : • L-iduronic acid → 90% • D-Glucuronic acid →10%	- **Anticoagulant** (ضدالتجلط) - Present in : • Mast cells • Lungs • Arterial walls • Liver - Bound to Ptns in Extracellular matrix
5. Heparan Sulfate	As Heparin But it contains : - More Glucuronic acid - Its Glucosamine residues contain less sulfate	- Bound to Ptns in Extracellular matrix - Present on may cell Surfaces as Proteoglcans

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NBs :

1. The Olnly GAG w` doesn't contain Sulfate is Hyaluronic acid
2. The Only GAG w` doesn't contain Uronic acid is Keratan sulfate

Proteoglycans

Definition :

GAGs w` are covalently linked to a Ptn core

Structure :

- 95 % ⟶ Carbohydrates
- 5 % ⟶ Proteins

Site : e` other Extracellular Ptns

- Extracellular matrix
- Ground substance in association e` extracellular Ptns

Functions and Importance of GAGs & Proteoglycans : *CALCA*

1. **C**omponents of Extracellular matrix
2. **A**ttract water by osmotic pressure into the Extracellular matrix causing swelling as GAGs w` is present in proteoglycans are Polyanions → bind e` cations like Na+ & K+ , so attract water
3. **L**imit the passage of large molecules into Extracellular matrix allowing passage of small molecules ; as they form gels at low concentration
4. **C**ompressibility of cartilage
   as cartilage is rich proteoglycans w` contain GAGs (polyanionic)
5. **A**ggrecan formation
   - Aggrecan is the major proteoglycan present in cartilage
   - Contains : *KCH*
     - **K**eratan Sulfate
     - **C**hondroitin Sulfate
     - **H**yaluronic acid
6. **Hyaluronic acid proteoglycan :**
   - Present in : Embryonic tissues
   - Important for cell migration & morphogenesis (تحور)
   - Its concentration is increased in cases of wound healing (repair)

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7. **Heprin :**
   - Anticoagulant → as it ;
     - Bind factor IX & XI
     - Activates Antithrombin III
   - Release the enzyme Lipoprotein Lipase (LPL) from the capillary wall to the Plasma , this enzyme helps removal of lipids from the blood So ; Heparin is called → Clearing Factor "clears blood from lipids"
8. **Keratan Sulfate proteoglycan** : Important for ;
   - Transparency of the Cornea
9. **Dermatan Sulfate proteoglycan** : Important for ;
   - Maintainance of Structure & Shape of Sclera of the eye
10. **Heparan Sulfate proteoglycan :**
    - Present in Plasma membrane of cells
    - Play important role in :
      - Cell membrane receptors
      - Cell-Cell Interaction

FORSAAN ASBAY

Non Reducing Disaccharides

Sucrose :

Other names : Cane Sugar , Table Sugar

Structure : α,D-Glucopyranose & β,D-Fructofuranose

Linkage : α1-2 Glucosidic linkage
or β2-1 Fructosidic linkage

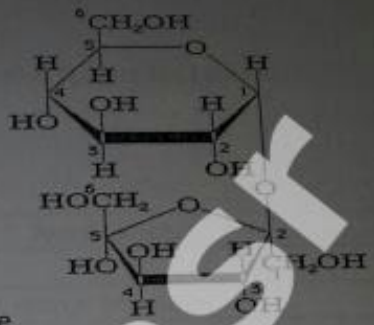
Present in : Cane & beets (البنجر)

Hydrolyzing enzyme : Sucrase

Hydrolysis Products : D-Glucose & D-Fructose

Non reducing ... Explain why ?

As Both the Annomeric Carbons are involved in the linkage
So doesn't have α or β forms & Can't mutarotate



Sucrose is Dextrorotatory → (+66.5) , On hydrolysis it gives :

- D-Glucose → +52.5
- D-Fructose → -92.3

This mixture is Levorotatory & termed Invert Sugar due to inversion of rotation& the enzyme Sucrase is also called Invertase

Sucrose (+66.5) —Sucrase (Invertase)→ D-Glucose (+52.5) + D-Fructose (-92.5)

—3.Polysaccharides

Polysaccharides

Homoplysaccharides	**Heteropolysaccharides**
Contain Only 1 type of monosaccharides	Contain More than 1 type of monosaccharides

I.Homopolysaccharides

- They are given names according to the building units :
  - **Glucans :** Formed of D-Glucose units & include
    - **Starch**
    - **Dextrin**
    - **Glycogen**
    - **Cellulose**
  - **Fructans :** Formed of D-Fructose units & found in plants as :
    - **Inulin**

↓

used to measure the Kidney Function

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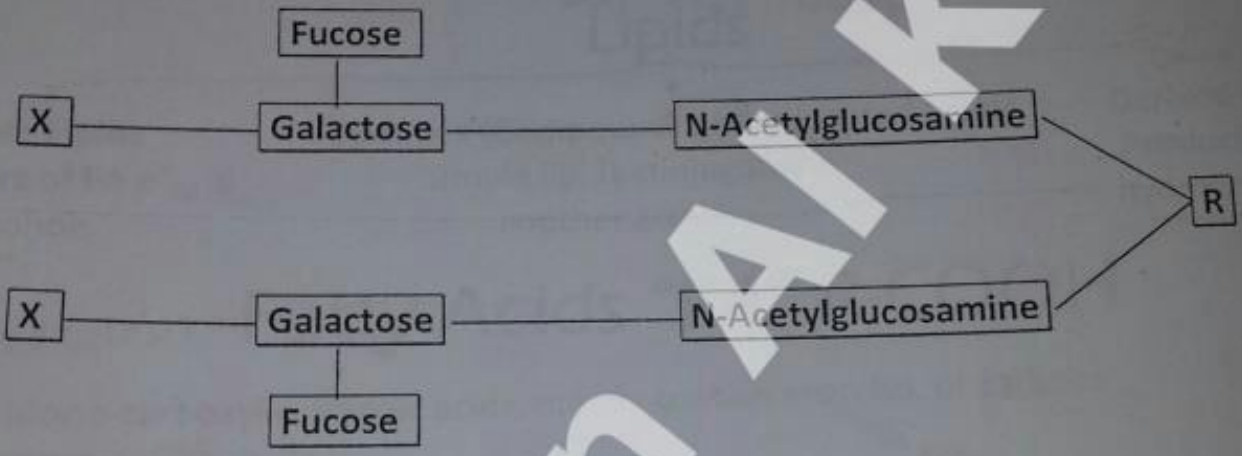
Glycoproteins

Site : Mucous , cell membrane & blood
Structure : Ptns containing short chain CHO (usually oligosaccharides)
% of CHO : 1 % in collagen
4 % in Immunoglobulins (Igs)
50% in mucin
85% in ABO blood group antigens

ABO Blood Group Antigens

- It's Glycoproteins
- The human blood groups A , B , AB & O depend on the oligosaccharide of the glycoprotein



R : is either :

- Protein molecule (Glycoprotein) or
- Lipid molecule (Glycolipid)

To this Glycoprotein or Glycolipid 2 Oligosaccharides chains (arms) are Connected

X : is variable w` indicates the blood group type :

- If X in both arms is Galactose → Blood group is B
- If X in both arms is N-acetylgalactosamine → Blood group is A
- If X is absent → Blood group is O : X is absent

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